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# A Review on Prediction of Municipal Solid Waste Generation Models

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**Abstract**

Development of a Municipal Solid Waste Management (MSWM) plan is a complex process. As a foundation and prerequisite for efficient MSWM plan, quantification and prediction of Solid Waste (SW) generation is very much essentials. Municipal Solid Waste (MSW) prediction cannot be done directly and depends on so many factors. In actual practices, due to uncertainties and unavailability of sufficient data, modelling methods are needed for prediction of MSW generation. A number of researchers have predicted SW generation using various modeling methods. The main objective of this paper is to review such models related to MSW generation using economic, socio-demographic or management-orientated data and identify possible factors that will help in selecting the crucial design options within the framework of mathematical modeling. Five characteristic classification criteria, namely, modeling method, area covered, time series, independent variables and waste streams are focused in this review. The entire published models are diverse in nature for application from whole country to households. Successful modeling depends significantly on selection of waste stream. From the review and discussion of models the research aims to identify the limitations of previous models which will help in identifying the crucial design options within the framework of modeling. The study is concluded with a few fruitful suggestions.



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## 1.0 Introduction

Solid Waste Management (SWM) is now one of the challenging issues for modern societies due to change in consumption pattern and uncontrolled urbanization and industrialization. Municipal Solid Waste (MSW) includes household, commercial, institutional, street sweeping, construction and demolition, and sanitation waste. MSW also contains recyclables (paper, plastic, glass, metals, etc.), toxic substances (paints, pesticides, used batteries, medicines), compostable organic matter (fruit and vegetable peels, food waste) and soiled waste (blood stained cotton, sanitary napkins, disposable syringes) (Sharholy et al., 2008).

Global Waste Management Market Assessment (2007), reported 2.02 billion tones MSW generation globally and annual increase rate of 8%. In India increasing urbanization and changing life styles, accelerate MSW generation in cities eight times more MSW than they did in 1947. About 90 million tons of MSW were generated annually (Sharholy et al., 2008). Per capita MSW generated rate increased to 1–1.33% annually (Bhide and Shekdar, 1998; Shekdar, 1999; Pappu et al., 2007). The composition and the quantity of MSW generated in India differ greatly with that in the western countries (Jalan and Srivastava, 1995; Shannigrahi et al., 1997; Gupta et al., 1998) particularly with hazards characteristics. Sharholy et al. (2008) mentioned that, MSW in urban areas contained large fraction of compostable materials (40–60%) and inert (30–50%). The relative percentage of organic waste in MSW was generally increasing with decrease in socio-economic status; so rural households generate more organic waste than urban households.

It has been noticed that the physical and chemical components of MSW depends upon a number of factors such as food habits, standard of living, degree of commercial activities, seasons etc. where the total MSW generation depends on total population. Effective collection and proper disposal of MSW depends greatly upon accurate prediction of generation of solid waste (Chang and Lin, 1997). MSW prediction cannot be made directly and depends on many qualitative and quantitative factors. Due to uncertainties and insufficient data availability, modeling methods were found to be beneficial.
The main aim of this paper is to review the published models related to prediction of MSW generation. The limitations of the previous models were also discussed to identify the crucial design options within the framework of modeling.

## 2. Study of MSW Prediction Models

Systematic reviews of various models on MSW prediction in this model may be regarded as an extension work of Beigl et al. (2008). The models related to waste generation upto 2005 were included in his work. This paper reviewed 20 MSW generation prediction models from 2006 to 2014. The waste generation prediction models are mainly based on decision –support system such as cost benefit analysis, multicriteria decision analysis and life cycle analysis. The reviewed models may be classified into five broad categories based on: modeling method, study area, time series, independent variables considered and waste streams.

### *2.1 Modeling Methods*

Conventional waste generation prediction models including correlation and regression models generally used demographic and socioeconomic factors. Various independent variables were considered in most of the prediction models. However, a grey fuzzy dynamic model developed by Chen and Chang, (2000) was not based on any independent variable (except the time series data with at least three values). Some models used bivariate analysis (only one independent variable) whose validation depends on real MSW data such as correlation and regression analyses, time series analyses, and group comparison. These models expressed only cause and effect.

Other models used multivariate analysis (more independent variables) such as input output analysis, system dynamics, artificial intelligent system (fuzzy logic, artificial neural network, genetic algorithms) and multiple regression methods. These modeling methods create complications due to diverse interactions with the variables. As a result validation of model becomes difficult. The models which were generally used to predict MSW generation within 2006-2014 are support vector machine (Abbasi et al. 2012), wavelet transform (Noori et al. 2009; Abbasi et